NOWCAST for the Next Generation Navy

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LONG-TERM GOALS

This project is one coordinated component of a larger effort to address specific operational decisions that are affected by meteorology and oceanography (METOC) processes. Our goal is to develop a high-resolution weather data fusion (NOWCAST) system capable of blending an ensemble of highly perishable, on-scene environmental data together in the context of operational situational awareness to provide a consistent, integrated picture of the current, real-time METOC impacts both in the target area and within the battlegroup. This system will benefit the warfighter by providing a common environmental situational awareness capability that can be accessed directly over the network by decision makers whenever their mission has environmental dependencies. The situational awareness of weather hazard information is intended primarily to support naval aviation in time critical strike missions but may also be used to improve safety, navigation, ship self defense, and weaponeering. The NOWCAST system will be owned, operated, maintained, and quality assured by the METOC office.

OBJECTIVES

The specific objectives of this project within the larger effort are to design and develop the prototype client / server NOWCAST data fusion system; to develop NOWCAST weather impact products using a wide variety of data sources, both conventional and "through-the-sensor"; and to obtain end-user buy-in through a series of high-level briefings and an Integrated Product Team (IPT) process. The IPT process is designed to ensure that the products developed for NOWCAST meet the warfighter's decision-making needs and that the METOC office can be responsible for NOWCAST operations.

APPROACH

To meet the challenge of utilizing METOC data available at asynoptic times collected by forward-deployed units, NRL has developed the Coupled Ocean/Atmosphere Mesoscale Prediction System – On-Scene (COAMPS-OS™). NOWCAST includes interfaces for the COAMPS™ gridded data fields and conventional observation data to the METOC FMQ-17 (shore) and SMQ-11 (shipboard) satellite data processing systems for satellite data and to a NOAA data feed for NEXRAD level II and level III radar data. When available, NOWCAST can also use data from non-traditional sources focused around the battlegroup and target areas. For example, AEGIS SPY-1 Tactical Environmental

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14. ABSTRACT

This project is one coordinated component of a larger effort to address specific operational decisions that are affected by meteorology and oceanography (METOC) processes. Our goal is to develop a high-resolution weather data fusion (NOWCAST) system capable of blending an ensemble of highly perishable, on-scene environmental data together in the context of operational situational awareness to provide a consistent, integrated picture of the current, real-time METOC impacts both in the target area and within the battlegroup. This system will benefit the warfighter by providing a common environmental situational awareness capability that can be accessed directly over the network by decision makers whenever their mission has environmental dependencies. The situational awareness of weather hazard information is intended primarily to support naval aviation in time critical strike missions but may also be used to improve safety, navigation, ship self defense, and weaponeering. The NOWCAST system will be owned, operated, maintained, and quality assured by the METOC office.

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Processor (TEP) and other tactical radars of opportunity can provide weather radar data around the battlegroup and unmanned aerial vehicles (UAV) can provide a rich set of target area weather observations. To use these unconventional data in real-time requires us to adapt machine intelligent feature detection and artificial intelligence (AI) data fusion techniques to create an automatic environmental data fusion engine. In addition, NOWCAST uses established web-based product dissemination and display technology to overcome fleet firewall policy limitations and minimize end-user training issues. The NOWCAST client software application is configurable to allow the warfighter to tailor their results to their specific requirements.

Another principal effort in this project is devoted to the development of high-level support and end-user buy-in to NOWCAST. To facilitate this interaction, a series of high-level briefings and meetings to senior Navy decision makers in the aviation, surface warfare, and METOC communities have been on going to expose the concept of NOWCAST and to generate support. This year, we proposed to partner with the Naval Strike and Air Warfare Center (NSAWC) and the METOC Detachment at Fallon to create a shore test and development site for NOWCAST to provide enhanced weather support to strike warfare. Although not yet funded, NSAWC reaction to the proposal was favorable and sponsorship is being pursued. We view the success of this project to be directly related to acceptance by the end-users. Without a feedback mechanism between the S&T process and the end-users, it is possible to be scientifically and technically correct, but produce results that are not useful. To this end, we also have well-defined involvement of selected end-users in the effort through an annual IPT process. The third annual IPT meeting was held at NRL Monterey on 25 and 26 June 2002.

Another key element of our approach is to leverage other projects at NRL and at other governmental agencies. The NRL Base program supports research projects to develop automatic product verification technology for NOWCAST and to adapt and develop techniques to fuse data to create accurate descriptions of cloud and wind fields to support carrier aviation operations and descriptions of electromagnetic (EM) propagation conditions. To improve the diagnosis of the three-dimensional cloud field, this NRL base project has implemented components of the University of Oklahoma's ARPS Data Assimilation System (ADAS) in NOWCAST. In another related area, NRL has a major Ceiling and Visibility (C&V) NOWCAST product development funded by FAA, NASA, and Navy (N096 through CNMOC and SPAWAR), to provide C&V NOWCAST products.

WORK COMPLETED

A prototype NOWCAST system was designed, developed, and demonstrated at NRL Monterey in FY00. NOWCAST leverages software developed for the NRL Atmospheric Variational Data Assimilation System (NAVDAS) for conventional data quality control.

The effort for FY01 was focused on acquisition and processing of new data types. In cooperation with the NRL Base project, a real-time data interface and processing capability for NEXRAD radar data was developed and transitioned to FNMOC. A C&V algorithm developed by the National Center for Atmospheric Research (NCAR) was implemented in NOWCAST to produce ceiling height and visibility products every 15 minutes. The ADAS three-dimensional cloud analysis from OU was implemented in NOWCAST and used to compute volume cloud elements every hour.

In FY02 the NOWCAST user interface was completely redesigned and recoded to overcome problems with the original prototype that limited functionality and caused unreliable performance. Several new features were incorporated into NOWCAST:

- User account and password management
- User configuration for areas, folders, and product tabs
- Ability to share folders among users
- Globally relocatable and zoom to tactical scales
- Extension to 3D products for height dependence
- Integration of product confidence level information
- Automatic update of displayed products
- Access to local radar and satellite data
- Ingest of NOWCAST product grids into TEDS
- Usability features to change units, time zones, titles, names, legends, and descriptions

Figure 1 is an example of the new NOWCAST applet showing a hazardous weather display consisting of the current radar reflectivity data and METAR surface observations. The user-selectable option to overlay a height-dependent product, for example wind vectors, is controlled by the slider on the left. Three-dimensional winds have been added to NOWCAST to support aircraft operations and are also being applied to automatically update chemical/biological dispersion assessments through support from the Joint Science and Technology Panel for Chemical and Biological Defense (JSTPCBD).

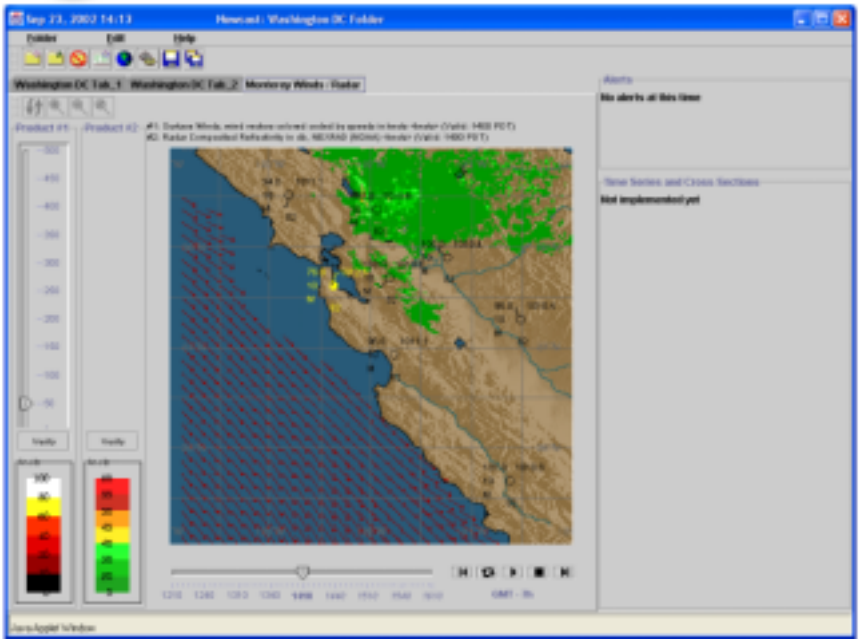

Figure 1. The NOWCAST user interface using JAVA web applet technology showing radar reflectivity data, METAR surface observations, and wind vectors near the surface over a map of the San Francisco, CA area. The slider on the left can be moved up and down to display the winds at different heights above the surface.

Work initiated last year was completed this year by a Navy Reservist at NRL who processed and analyzed a large amount of TEP radar data collected onboard the USS Normandy during a Joint Task Force Exercise (JTFX). These data were the core of a Thesis at the Naval Postgraduate School (NPS), Department of Meteorology, that investigated the utility of TEP as a Doppler weather radar at sea

(Robinson 2002). One of the cases showed a squall line and severe downburst that disrupted flight operations during the JTFX. The storms formed along a mesoscale air mass boundary that was identifiable on radar but forecasting exactly when and where the thunderstorms developed was not possible. We speculate the if NOWCAST were used to blend the data and forecast the development of thunderstorms, the ship could have had 30 min. warning and moved to avoid the adverse weather. This analysis shows promise that NOWCAST could improve automated thunderstorm detection and avoidance at sea; however, the data contained a number of artifacts and clutter that had to be manually removed. The automated quality control and processing of mobile radar data remains a scientific and technological challenge that is being addressed in a proposal for an NRL Base program new start. Additionally, this year a series of NOWCAST briefings were conducted at Johns Hopkins University/Applied Physics Lab, the National Reconnaissance Office (NRO), the Naval War College (Weather in the Cockpit Workshop), Oceanographer of the Navy (N096), Commander Naval Meteorology and Oceanography Command (CNMOC), SPAWAR PMW 155, Naval Postgraduate School (NPS), and the Naval Strike and Air Warfare Center (NSAWC). The third NOWCAST Integrated Product Team (IPT) meeting was also held this year at NRL Monterey. The meeting was attended by a mix of warfighters, engineers, scientists, managers, and METOC decision makers and resulted in a lively exchange of information, requirements, and concerns about the role, design, development, and fielding of an operational NOWCAST capability. The NOWCAST web site at http://www.nrlmry.navy.mil/Apps/nowcast contains the presentations from the IPT meeting.

RESULTS

The performance limitations of the prototype NOWCAST system required the user interface be redesigned and recoded in FY02. The new system is more reliable and more responsive while requiring less network bandwidth and maintenance. User functionality was enhanced with the addition of global relocatability, full user control over folders, tabs, products, and a height-dependent display capability. Users can now view any level of a volume product as an overlay on the base map.

In coordination with the 6.2 NRL Base project, the developmental NOWCAST system was cycled every hour and we learned that the ADAS 3D cloud analysis consistently improves upon the COAMPS forecast background conditions. Using both the equitable threat score for total cloud amount and cloud top temperature correlation, ADAS improved upon the COAMPS background forecast. In terms of what the end user might see for verification, NOWCAST provides a simple cloud confidence score that showed 92% (ADAS) vs. 80% (27 km COAMPS). By this score, ADAS improves the confidence of assessing where there is cloudiness by more than 10% over the COAMPS background forecast.

The annual IPT reinforced the warfighter's priorities for data fusion and decision-enabling products in the target areas, enroute, and in the carrier launch and recovery areas. NOWCAST needs to supplement existing METOC forecast assets with an automated capability to continuously assimilate and fuse observations from all sources including "through-the-sensor" observations. NOWCAST also needs to include intuitive quality control features so that the system is easy to use, operate, maintain, and monitor, and the system needs to be designed to minimize training requirements. NOWCAST needs to interface to the Naval Fires Network (NFN) and other C^2 architectures, such as ForceNet, to help realize the benefits of net-centric warfare and the four-dimensional battlespace awareness cube.

IMPACT/APPLICATIONS

NOWCAST is the focus of a telescoping strategy to provide environmental products tailored to the decision-making needs of the warfighter, from global scales down to tactical scales in both time and space. NOWCAST also represents a paradigm shift from periodic products that are briefed and interpreted by METOC personnel to (nearly) continuous products that are easily accessible, automatically updated, and tailored for interpretation directly by the warfighter. NOWCAST enhances the role of METOC support by supplementing the existing forecast capability with automated, short-term (less than 2 hours) decision-enabling products, thus freeing the forecaster to concentrate on the longer-range projections for planning and evaluation purposes.

TRANSITIONS

NOWCAST has a three-phase product development cycle. Phase 1 and 2 products are either in operations or in the current R&D pipeline. NOWCAST, including the phase 1 and 2 products are expected to begin transition in the 2005-2006 time frame to the 6.4 Navy Integrated Tactical Environmental Subsystem (NITES) program at SPAWAR PMW 155. An early transition in FY01 was a stand-alone radar capability implemented at FNMOC. Phase 3 products for NOWCAST require additional resources and R&D and are not expected to transition before 2006.

RELATED PROJECTS

The SPY-1 TEP project at ONR is important to NOWCAST as a source of weather radar data at sea.

A major component of NOWCAST development is the project in the NRL Base program (BE-35-2-56) to develop cloud diagnostic algorithms and verification software for the NOWCAST system.

The tri-service (FAA, NASA, and Navy) C&V project has transitioned to an FAA National Ceiling and Visibility Product Development Team.

NOWCAST was demonstrated at NPMOC-SD during Fleet Battle Experiment - Juliet (FBE-J).

Automated chemical and biological dispersion products are being integrated with NOWCAST and COAMPS-OS™ under sponsorship by the Joint Science and Technology Panel for Chemical and Biological Defense (JSTPCBD).

SUMMARY

NOWCAST will provide the Navy METOC operator with an automated system to help monitor and characterize rapidly changing, operationally significant weather situations. By providing information over the web, NOWCAST will enable warfighters and decision-makers to consider the impacts of the environment within a common situational awareness framework. This commonality should help to improve coordination and efficiency on the battlefield.

PUBLICATIONS

Robinson, LT Sean D. (2002): Utility of the Tactical Environmental Processor (TEP) as a Doppler Weather Radar at Sea. Naval Postgraduate School, Department of Meteorology, Masters Thesis. Monterey, CA.